KLS Vishwanathrao Deshpande Institute of Technology

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DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

University / Model Question Paper

Scheme & Solution

Faculty Name	:	Dhwina
Course Name	:	Hybrid Electric vehicle
Course Code	:	MLTE204
Year of Question Paper	:	June/July 2025
Date of Submission	:	10/12/25

Faculty Member

HoD

Head of the Department
Dept. of Electronic & Communication Engg

Dean (Acad.)

DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGG
KLS VDIT HALIYAL

CBCS SCHEME

USN | 2 | V | 23 | 24 | L | H | E | 09 |

MLIE204

Second Semester M.Tech. Degree Examination, June/July 2025
Hybrid Electric Vehicles

Time: 3 hrs. Max. Marks: 100

Note: 1. Answer any FIVE full questions, choosing ONE full question from each module.
2. M : Marks , L: Bloom's level , C: Course outcomes.

			M	L	C
		Module – 1			
Q.1	a.	Explain the concept behind EV.	10	L2	CO1
	b.	How fixed and variable gearing work.	10	L2	CO1
		OR			
Q.2	a.	Explain single and multiple motor drives.	10	L2	CO1
	b.	Explain Well To Wheel Analysis.	10	L2	CO1
		Module – 2			
Q.3	a.	Explain the choice of propulsion system.	10	L2	CO2
	b.	Explain the classification of EV Motors.	10	L2	CO2
		OR			
Q.4	a.	Explain block diagram of EV Propulsion.	10	L2	CO2
	b.	Explain Four quadrant dc choppers.	10	L2	CO2
		Module – 3			
Q.5	a.	Explain single phase ARS inverter technology.	10	L2	CO3
	b.	Explain 3-phase full bridge voltage fed inverter.	10	L2	CO3
		OR			
Q.6	a.	Explain how sliding mode controller work.	10	L2	CO3
	b.	Explain two quandrant DC Chopper.	10	L2	CO3
		Module – 4			
Q.7	a.	Explain different configuration of HEV.	10	L2	CO4
	b.	Give the examples for the power flow control.	10	L2	CO4
		OR			
Q.8	a.	Explain Power Flow Control.	10	L2	CO4
	b.	Explain examples of HEV system performance.	10	L2	CO4

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		Module – 5			
Q.9	a.	Explain standard power levels of conductive chargers.	10	L2	CO5
	b.	Explain characteristics of Battery.	10	L2	CO5
		OR			
Q.10	a.	Explain different batteries and ultra capacitors.	10	L2	CO5
	b.	Explain Domestic Charging Infrastructure and Public Charging Infrastructure.	10	L2	CO5

Hybrid Electric Vehicles MLIE 204

June/July 2025

1) a) Explain the Concept behind EV 10m

=> Energy Source - Rechargeable batteries store Electric Energy

Propulsion - Electric motors Converts this Energy into mechanical motion

Control System - power Electronics regulate motor Speed torque and Efficiency

Charging: Energy is replenished via grid Electricity renewable Sources.

b) How fixed and variable gearing work 10m

=> Gearing is a mechanism that determines how torque and Speed are transmitted from the motor to the wheels -

Fixed Gearing:-

A Single Constant gear ratio is used the motor or rides speed directly translate to wheel speed through one gear ratio

A gear pair is set with a fixed number of teeth the gear ratio is determined by

[Text{ Gear Ratio } = \frac{\text{Text{ number of teeth on driven gear }}}{\text{Text{ number of teeth on Driving Gear }}}]

Variable gearing work:- Variable gearing means that gear ratio between input and output can be changed during operation allowing the system to adapt torque and speed to different conditions

* A variable speed gearbox variable ratio transmission adjusts the relationship between input shaft speed & o/p shaft speed. this can be achieved by step-change gearboxes.

2 a) Explain single and multiple motor drives 10m

Single motor Drives:- It means the vehicle uses one electric motor to power either the front wheels or rear wheels this is the simplest and most common c

=> motor placement :- Front axle -> powers front wheels
=> Rear axle -> power rear wheels
=> Power Electronics - an Inverting converts DC battery power into AC for the motor.
=> Control - motor torque and speed are regulated by converters and controllers

multiple motor Drives:-

multiple motor Drives use two or more motors to power different axles or even individual wheels this Architecture improves performance, Efficiency and control flexibility

Dual motor Drive:- one motor powers the front wheels another powers the rear wheels

3 a) Explain the choice of propulsion system.

=> Propulsion system selection is a critical engineering decision based on optimizing performance, Efficiency Cost and reliability for a specific application.

=> Operating Environment & application :- Aircraft Require high speed high thrust s/m

=> Performance Requirements :- Speed acceleration and load capacity dictate Power needs for instance, fast boats require different systems.

=> Efficiency & Cost :- Diesel - Electric s/m are preferred for lower maintenance and constant speed Efficiency while Electric motors provide quiet

=> Space & weight constraint :- Spacecraft Propulsion must maximize specific impulse while minimizing mass

3 b) Explain the classification of EV motors

=> EV motors are primarily classified into AC and DC types

=> AC motors :- Permanent magnet Synchronous motors are efficient and compact commonly used for performance and long range

AC Induction motors :- Rugged reliable and cost effective often used in performance oriented vehicle

* Enables all-wheel drive without a mechanical driveshaft
* motors can be controlled independently for traction and torque distribution

-> In-wheel motor Drive:
* motors are integrated directly into each wheel hub
* Provides precise torque control per wheel
* multi-motor s/m:- Four motor maximum control and redundancy, used in advanced EV and autonomous vehicles for stability and agility

2.b) Explain well to wheel analysis (5m)

=> It is a well to wheel analysis comprehensive method to asses the total energy consumption and environmental impact of a vehicle or fuel pathway tracing it from raw material extraction through processing, distribution and ultimately to its use in the vehicle.

=> well-to-tank → Covers everything before the fuel gets to the vehicle

=> tank to wheel - Focuses on the vehicle direct energy use.

* a gasoline car has lower WTT.
* an Electric car has higher WTT

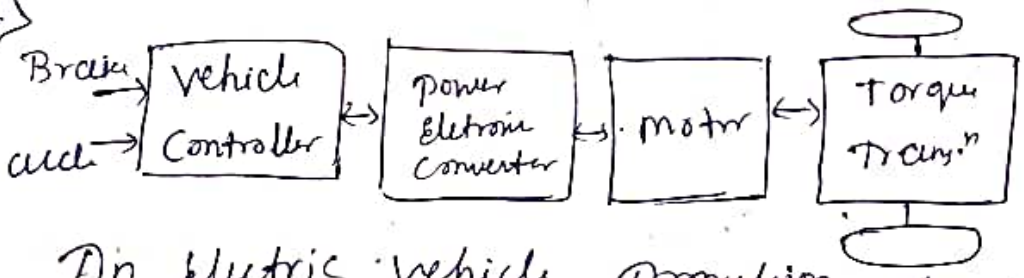
* DC motors – Brushless DC motors:- Known for high efficiency and high starting torque often used in smaller electric vehicles
* Brushed DC motors:- Older technique rarely used in modern EV due to maintenance needs and lower efficiency

=> Switched Reluctance motors:- Robust and simple though they can have noise and control challenges.

=> Axial flux motors:- A modern high power density motor type designed for better efficiency often used for hub motors.

4 a) Explain block diagram of EV propulsion 10m

=>



An electric vehicle propulsion system converts stored electrical energy into mechanical power to drive the wheels replacing the internal combustion engine. It includes a high voltage battery an inverter an electric motor

Battery Energy Source – Stores DC Energy and provides Power to entire Powertrain

DC-DC Converter:- steps down the high voltage DC from the battery to a lower voltage to power auxiliary

SIm

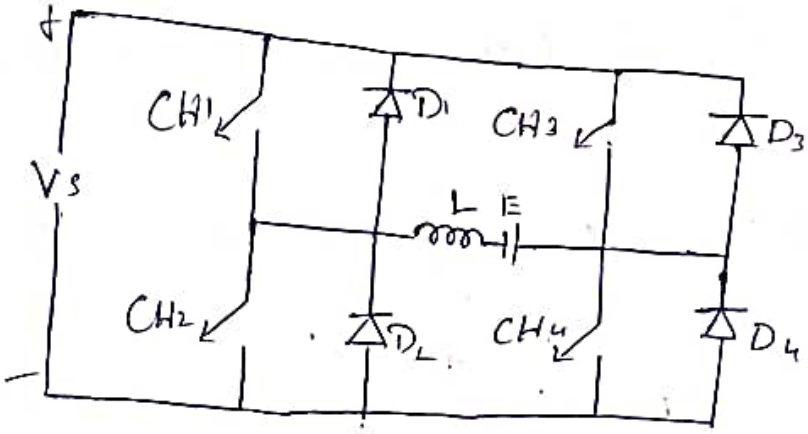
* Inverter – Converts DC from battery into variable frequency AC

* Electric motor – Converts Electrical Energy into mechanical Energy types include induction magnet motor

* transmission : - A fixed gear ratio transmission transfers torque from the motor to the wheels

* Vehicle Control Unit : - the brain of the system controlling the Inverter based on driver input

4 b)



=> A Four-Quadrant DC Chopper is a Power Electronic Converter that Controls a DC motor speed and direction by Enabling both +ve/-ve output voltage and current

It uses four switches ($CH_1 - CH_4$) and four diodes ($D_1 - D_4$) in an H-bridge Configuration to operate in all four Quadrants

Q1 - Forward motoring (+V +I)

CH4 is on CH3 is OFF CH1 is pulsed

Q_2 - Forward Braking (+V, -I)

CH_2 is pulsed CH_1, CH_3, CH_4 are off

Q_3 - Reverse motoring (-V, -I)

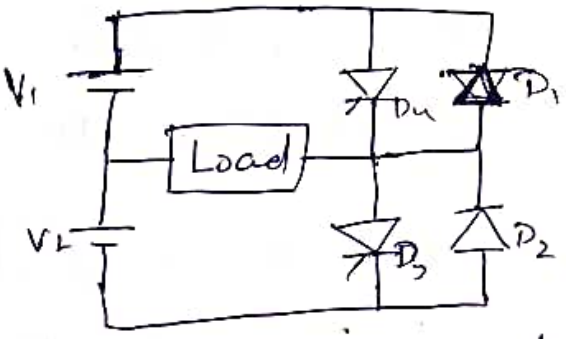
CH_2 is ON CH_1 is OFF and CH_3 is pulsed

Q_4 - Reverse Braking (-V, +I)

CH_4 is pulsed CH_1, CH_2, CH_3 are off

5a) Explain Single Phase AR5 inverter technology ion

=>

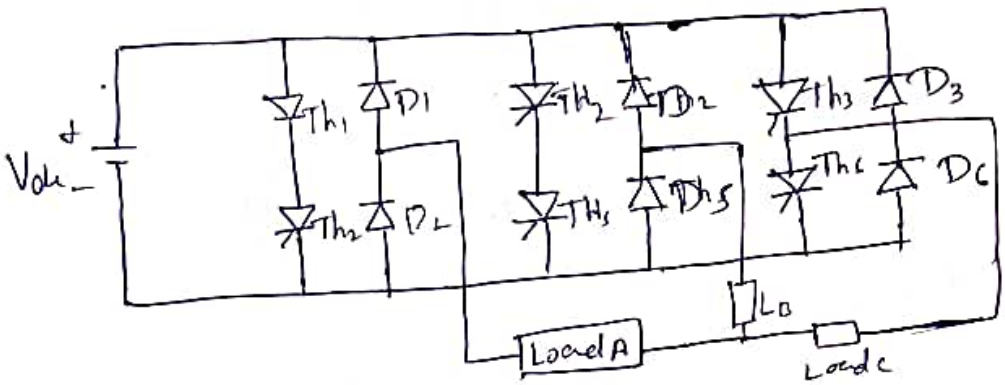


=> Single phase Inverter technology converts direct current power typically from solar panels or batteries into a single phase altering current output to power residential appliance it is commonly used in residential setting because it matches standard household Electrical infrastructure

* DC Source - Batteries or other DC sources
* Inverter circuits :- H bridge uses 4 switching elements to turn on the DC input on and off to generate an AC waveform

5b) Explain ~~single~~ 3-phase full bridge voltage fed Inverter

=>



=> It Converts constant DC input voltage into a variable frequency 3phase AC output using six switches in a bridge configuration it commonly operates in 180° or 120°.

=> Structure - It Consist of three legs each having an upper and lower Switch with associated feedback diodes

=> Switching Sequence:- the six switches are triggered at 60° intervals to produce full cycle of 3 phase o/p.

=> Voltage Source:- Voltage fed implies the DC input is from a stiff voltage source Ensuring a stable input voltage

=> output control: Pulse width modulation is typically used to Control the magnitude and frequency of the AC output voltage

6 a) Explain how sliding mode controller work

=> It is a robust nonlinear control technique that forces the system states to reach and stay on a Predefined sliding surface

=> the Controller defines a sliding surface a target state when the error between the desired performance and actual performance is zero

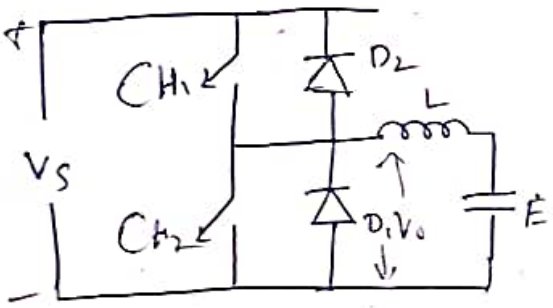
-> Reaching phase - the Controller forces the EV s/m state motor speed towards this surface from any initial state

-> Sliding phase:- Once the state hits the surface the smc maintain the system on it

=> Robustness - smc handles nonlinear and parameters uncertainties efficiency, ensuring stability

6 b) Explain two quadrant DC chopper

=>



=> 2 quadrant DC chopper is a power electronics converter allowing two modes of operation forward motoring and regenerative braking maintains positive output voltage while allowing current to reverse commonly used for controlling DC motor speed and direction

* Circuit Structure:- typically consists of two switches (CH_1, CH_2) and two anti parallel diodes (D_1, D_2)

* First Quadrant :- CH_1 and D_1 operate when CH_1 is ON $V_o = V_s$ and current flows from the source to the load when CH_1 is OFF D_1 free wheels

=> Second Quadrant -> CH_2 and D_2 operate when CH_2 is ON the load voltage V_o is zero and current rises in the -ve direction storing energy in the inductor when CH_2 is OFF D_2 conducts

7 a) Explain different configuration of HEV

=> Series HEV configuration:-

* mechanism - the ICE is mechanically decoupled from the wheels and acts solely as a generator to charge the battery

=> parallel HEV configuration:-

mechanism - Both the Engine and Electric motor are connected to the transmission via a common driveshaft allowing them to drive the wheels

=> Series - parallel HEV - Combines features of both using a planetary gear set to allow the Engine to drive the wheels directly while simultaneously running the generator

=> Mild Hybrid - Features a smaller Electric motor and battery that cannot propel the car on its own

7b) Give the Examples for the power flow control

=> power flow control manages Electricity distribution to prevent line Congestion and improve grid Efficiency In EV it manages the Energy between the battery motor and grid to optimize Efficiency and Safety using Inverter

=> Pulse width modulation - Adjusting the duty cycle to regulate the average voltage supplied to the motor

=> Vector Control :- Precisely controlling torque and speed by managing the magnetic flux components of the motors current

=> Battery management Systems - Ensuring power flow remains within safe limits for battery temperature and health

=> Examples - vehicle to Grid, multi mode traction in Hybrid, Auxillary power management.

8)a Explain the Power Flow Control

=> It manages the bidirectional transfer of Electrical Energy between the batter Inverter and motor using Power Electronics to optimize Efficiency speed & torque. It Enables Acceleration by driving the motor and Enables regenerative braking by converting kinetic Energy back to charge the battery

=> motor Controller- the central unit receiving torque Signals controlling the power flow to the motor for acceleration.

=> Bidirectional converter- manager energy flow between the battery and the DC link.

=> Regenerative Braking- when the throttle is released are applied the motor acts as a generator converting rotational Energy into Electrical Energy to charge the battery.

=> Control strategies - algorithms and modulation techniques within the inverter adjust voltage.

8 b) Explain Examples of HEV s/m performance

=> It is characterized by the intelligent Combined use of an internal combustion Engine and an Electric motor to maximize fuel Efficiency reduce Emissions and Enhance driving dynamic

1) Low speed -> at low speeds or in stop and go traffic the Ev motor Drives the wheels Exclusively

2) acceleration and "torque assist" - when Extra power is needed for overtaking rapid acceleration the Electric motor Supplements the Engine

3) Regenerative Braking:- when braking the Electric motor reverse its roles to act as a generator. Converting Kinetic Energy into Electricity to recharge the Battery

=> Highway Driving - At high Speeds the Engine takes over as Primary Power Source as it operates at its most Efficient Speed range.

9) Explain Standard power levels of Conductive Charges

=> Level 1 - charging (Slow charging)

Power : 1.3 KW to 2.4 KW

Voltage : 120 V AC

Usage : Standard residential 3-prong outlet Charges at 3-5 miles of range per hour

=> Level 2 charging (medium speed)

Power : 3 KW to 22 KW

voltage : 209 V - 240 V AC

Usage - Residential, commercial and public parking lots

=> Level 3 charging (DC fast charge)

Power : 25 KW to 350 KW

voltage : 400 V to 1000 V DC

Usage : commercial stations Charges 80% in 20-60 min

9b) Explain characteristics of Battery

=> Voltage: the Electrical potential difference driving current. determined by battery chemistry

=> Capacity: the total charge a battery can store and deliver indicating how long it powers a device.

=> Energy Density: How much Energy per unit weight it holds impacting size/weight

=> Power Density:- How much quickly Energy can be delivered.

=> Discharge rate: How fast current is drawn relative to capacity affects available capacity

9a) Explain standard Power levels of conductive Chargers

=> Level 1 charger (slow - AC)

Power: 1.3kw - 2.4kw

I/p: 120V AC

Usage: Standard household Outlet.

=> Level 2 charging (medium)

Power: 3kw - 22kw

I/p: 208V - 240V AC

Usage: Homes, workplace

Level 3 - Charging (DC fast charge)

Power: 50kW - 350kW

Ps: high Voltage Direct

Usage: Commercial highways

=> IEC 62196 modes:- Conductive charging is also categorized by modes with mode 3 and mode 4 representing standard communicative and safe power transfer

=> Connector types:- type 1 supports up to 19.2kW while type 2 supports up to 43kW AC

10 a) Explain different batteries and ultra capacitors

=> Lithium-ion - the gold standard for modern electronics like smart phone and electric vehicle due to its high energy density and light weight design

=> Nickel metal Hydride:- Common in household rechargeable batteries hybrid cars and older laptop

=> Lead acid:- the heavy duty choice for car starters and backup power they are inexpensive but heavy and have a shorter lifespan

=> lithium Iron Phosphate:- A safer Lion variant with a much longer cycle life popular for off grid solar systems

10 b) Explain domestic charging infrastructure and Public charging infrastructure.

Domestic Charging:-

=> In involves installing 230V AC slow chargers often costing 1500-6000 for basic setups requirements include a dedicated accessible parking spot and in India 20% of buildings Parking must be EV ready to support this infrastructure

=> Charging types must home use AC slow charging typically utilizing 15A socket for daily overnight charging

Public charging

=> It Enables electric vehicle charging in accessible non residential locations crucial for reducing range anxiety and supporting long distance travel crucial for reducing range anxiety and supporting long distance travel key components include level AC charging and DC Fast charging located at Public parking highways and commercial hubs

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